LACE, Inc.

MANUFACTURERS AND DEVELOPERS OF WIRED AND WIRELESS LOCAL AREA NETWORK EQUIPMENT

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15 1996

July 12, 1996

Office of the Secretary
Federal Communications Commission
1919 M Street NW
Washington, D. C. 20554

RE: NPRM 96-193, ET Docket No. 96-102
Comments of Chandos A. Rypinski

Gentlepersons:

Attached hereto are nine copies of my Comments in the referenced matter.

Also enclosed is an additional copy of this letter and first page which I request be stamped and returned to me as evidence of delivery

Thank you.

Cordially,

Chandos A. Rypinski

0+8

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	NPRM 96-193 (May 6, 1996)
Amendment of the Commission's Rules to	)	ET Docket No. 96-102
Provide for Unlicensed NII/SUPERNet	)	RM-8648
Operations in the 5 GHz Frequency Range	)	RM-8653
	)	

July 12, 1996

COMMENTS OF CHANDOS A. RYPINSKI
President, LACE Inc.

1.0 Introduction

The primary purpose of these comments is to place in consideration both example rules and a frequency plan for the subject NII/SuperNet frequencies at 5.15-5.35 GHz. By being specific, it is hoped that the critical points will be addressed sooner The criteria used are as follows:

a) The plan has to be politically possible in the sense that the functional needs of known major contending uses for the space are addressed and at least partly satisfied.

b) The regulatory technical constraints defined must enable and encourage intensive frequency reuse without which the volume markets desired cannot be realized.

c) The partitioning of available spectrum proposed is that between necessary service types which have greater difficulty in using the same frequency and geographic space.

d) The possibility of selective use of the allowed technologies within the limits of private premises is proposed to avoid loss from differences in choice in different places. A band for a service not used in a particular premise may be used for more capacity of what is used.

e) The services supported are much higher data rate and capacity than have been provided for private use so far. Existing services are not duplicated or increased in quantity.

f) To offset the disadvantage of short reach end links, relay link provisions are an integral part of the plan.

g) To further increase the usefulness of this allocation, more liberal power rules are recommended outside of the metropolitan areas to reduce costs for low density users.

(The TABLE OF CONTENTS is on the following page)

TABLE OF CONTENTS Page

Before the
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In the Matter of	)	
	)	NPRM 96-193
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COMMENTS OF CHANDOS A. RYPINSKI

President, LACE, Inc.

1.0 Introduction (see cover page)

1.1 Summary of Proposal

These comments define four necessary and appropriate transmission technology applications: 1) peer-to-peer including HIPERLAN, 2) very high rate (VHR) wideband, 3) longer reach (LR) wideband and 4) LR channelized narrower band. These functions are needed for point-to-multipoint end links and must be supported by coordinated point-to-point relay links. A starting point proposal for allocation of the 200 MHz low band divides this space into 6 sub-bands:

1) 7 x 2 MHz for narrow band end links,
2) Peer-to-peer band corresponding to HIPERLAN channel 0 or like spectrum function,
3) Wideband channel 1 corresponding to HIPERLAN channels 1 and 2 usable for the Type II version with centralized control but also usable for any centralized control LAN,
4) Wideband channel 2 for very high rate modulations with centralized control,
5) Wideband channel 3 for channel coded longer reach modulations, and
6) 7 x 2 MHz for narrow band relay links.

For these uses, envelope rules are offered for consideration. These specifics are not proposed for literal adoption but as a means of displaying considerations that should go into the choices made.

While preferred uses for the wideband channels are indicated, it is proposed that the property owner within the limits of controlled access have the option of selecting any acceptable modulation in any of the bands. This enables use of different technologies in the same bands on different premises.

It is further proposed that public access infrastructure can be furnished by service providers on public access premises.

1.1 Fundamental Questions

The fundamental questions raised by Chairman Hundt at the conclusion of the recent en banc hearing (March 5, '96) on the ET Docket were:

1. Where is the waste and inefficiency in the present use of the spectrum?

2. Where is the spectrum going to come from to provide for new and better services?

The present proceeding is part of the answer to the second question. These comments will address the first question by example applied to the subject frequency space. The recommendations made are the essentials of much more intensive utilization of radio spectrum.

1.2 Causes of Inefficiency in Spectrum Use

The root cause of inefficiency is not technical, but societal—the recurring inability of multiple organizations (and their suppliers) to cooperate and solve their communications problems collectively instead of individually. For ubiquitous access and interconnection to other wired networks infrastructure is essential. Infrastructure is cost-effective only when cost is shared by large numbers of users. The potential of numerous stand-alone overlaid independent systems is already well exploited. *Infrastructure does not automatically mean third party service providers*—it is a technology equally useful and needed in high capacity private systems.

Apart from the public service providers, there is only a minor constituency for maximizing spectrum utilization by aggregating many different user groups into a shared infrastructure. While there are technical solutions that can be provided, there is no market for such solutions until the "cooperation" problem becomes manageable.

1.3 Other Points

Most of the new technology and radio applications require an order of magnitude or more increase in speed and capacity. The condition for this increase and its associated economic benefits is that new spectrum be allocated and used in new ways favorable to user cooperation—one building and one infrastructure for wireless access. A suitable regulatory environment is a vital step, but many more must follow.

The FCC deserves praise for the continuing effort to provide unlicensed services despite opposition from some incumbents and special interests. This has required some courage and resolve. The benefits can and will be very widespread. The result of this proceeding can make it possible for radio communication regulation and technology to make some very constructive improvements in national economic efficiency.

1.4 Qualifications

Chandos Rypinski is a graduate Electrical Engineer (Cal Tech) with a working career started in 1948 continuing to now. He has been a major design contributor to mobile telephone and data services since 1960 continuing to 1983. This work has been recognized by the IEEE Fellow Grade, Centennial Medal and Avant Garde (VTG) awards and by the Radio Club Fellow award.

He has been a member of the IEEE 802 Standards Committee for the last 11 years serving on the two integrated services and the wireless LAN Committees within 802. He has served for many years on the US delegation to SG8 and TG8/1 (ITU-R) intensively in some years. He has participated in WINForum since its organization, and is now a Director.

He has been a President, Engineering Vice-president and Consultant in several smaller Companies whose customers were usually the larger Companies. He is presently self-employed in a Company developing technology for ATM-based radio network access.

1.5 Order of Presentation

Section 2.0 discusses and defines the types of systems which are difficult to mix on a common frequency allocation bandwidth, but which must be supported to enable complete radio system designs for various applications.

Sections 3.0 and 4.0 are what is proposed. The following Section 5.0 "Discussion of Specific Points Pro and Con" Section goes into some detail on the most important considerations. This part is the justification for much of what has been recommended.

A point-by-point discussion and cross reference is given Section 8 following the general recommendations and comments.

It is not expected or even urged that the Regulatory Technical Requirements shown in 4.0 be adopted, but it is important to show some possibilities which would not otherwise be under consideration. All recommendations are independent of any particular product, though many existing products/technologies would fall within the constraints proposed. Everything proposed is believed to be near the least cost way of achieving the necessary function in a volume context

1.6 Basis for Better Efficiencies

The view is not to further divide spectrum any more than is essential. Cooperation between users may be obtainable by avoiding any alternative. (This was done in cellular licensing) The high capacity proposals do not avoid interference—but do enable methods of minimizing it.

Efficiency will result from use of many short reach access-points integrated with supporting point-to-point relay links. *Unused capacity must be gathered into the largest possible pool.* All users must be constrained from transmitter ON except when something useful is being transmitted.

There are large constituencies for other views on efficiency—that of peer-to-peer topologies. A plan requiring wide consensus must provide for the further use of this type of technology regardless of reservations about its effectiveness

A second level of usefulness outside of the obvious metropolitan areas can be obtained. Different low density tradeoffs are appropriate and necessary for rural communication.

2.0 Major System Types Described

It is necessary to define systems types since there are serious but not necessarily insoluble compatibility problems in mixing types in a shared frequency band. "Full band" is used to characterize systems in which transmitter energy fully occupies the allocated channel and that no channel switching function is required in the control functions. "Common channel" has the same meaning.

Table I – Types of Radio Systems

a) Peer-to-peer topology primary—deferral based channel access allowed—full band (* Part 15 DS and frequency hopping channelization allowed equally)

b) Centralized control with infrastructure primary—asymmetric up/down links—point-to-multipoint—full band—VHR and DS spread spectrum

c) Frequency division channelized—parallel lower rate long reach channels—point-to-multipoint centralized control

d) Point-to-point systems with fixed high gain directive antennas—full or channelized band—bands limited to outdoor use

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If the same bandwidth were independently allocated to each of the first three types, by far the centralized control would provide the highest capacity at acceptable interference levels for:

> a continuous carpet of service coverage over an area requiring large numbers of access-points and intensive frequency reuse.

A quite different answer is obtained for an isolated group or from disregard of interference-limited frequency reuse considerations. The efficiency or optimization criteria used maximizes:

Megabits/second of data transfer rate per Unit land/floor area per MHz of allocated spectrum

2.1 Peer-to-Peer Topology Primary—Deferral Based Access Control

Many of those supporting "listen-before-send access methods are also proponents of fully distributed logic which avoids infrastructure and central control function. Also, it is almost the only method by which "polite" unrelated groups could share a band without any a priori coordination. Sharing with impolite users produces a different result.

The 802.11 model (in year '93) was based on ad hoc, autonomous groups forming and disappearing. This model suits the use of the technology of 802.3 wired LANs that were then (and still are) in wide use. The obvious effort was to adapt the listen-before-send method of the duplex wired LAN in a contained environment. The adaptation to the unconfined simplex radio environment is not fully achievable. The majority (1993) in the 802 Committee favored the method and the operating model that went with it.

Having no central control and time reservation mechanism, such systems cannot provide a connection-type service. The addition of a point-control function (PCF) has been added to 802.11, but without including positive channel control. The PCF does have a function in linking a number of access-points to a shared LAN backbone.

The 802.11 standard has now evolved with efforts to mitigate the known limitations of the access method. There is now an adaptive backoff mechanism metering the time length for which the channel must appear clear before a new transmission can be initiated, and there is an attempt to making stations aware of transmissions by unheard stations by noting setup messages from those that are heard. After these and other modifications, the access method is no longer is simple.

There are three types of physical mediums so far recognized and which depend on listen-before-send access control: 1) 802.11 frequency hopping (FH), 2) 802.11 direct sequence spread spectrum (DSSS), and 3) HIPERLAN narrow band high rate with adaptive equalization.

Channelized FH and HIPERLAN provide more megabits per MHz than spread spectrum systems with the isolated group model. If it is assumed that interference is largely from like-type systems operating cochannel, the difference in spectrum capacity is nearer to equal. The DS and HIPERLAN are full band transmission in the sense that they fully occupy the allocated channel and there is no automatic channel switching plan defined in the station logic. Control logic is different when there is one RF channel that is time-shared compared with the case where allocated spectrum is subdivided into channels and user stations are switched between them (radio telephone model).

The mandatory "Etiquette" of the 1.92 GHz UTAMs band and that proposed for the subject 5.15-5.35 GHz is a deferral system. Because the constituency is so large, deferral systems must continue to be allowed within defined boundaries; but there should be no pretense that they are efficient, predictable, accurate or the main use. Etiquette should be permitted but not required or defined.

2.2 Centralized Control With Infrastructure—Asymmetric Up/Down Links—Full Band

This description, except for the "full band," fits traditional mobile telephone systems where there are base stations associated with a central controller providing an interface to external networks. Public radio telephone network CDMA fully fits the characterization though the presently specified method would not fit a multiple network open entry environment.

It is this similarity to service provider networks which is "frightening" to many in the computer industry. They see this type of technology as an invitation to service providers to "invade their turf" when in fact it is a technology description that is entirely neutral on whether it is installed by a premises owner or a third party provider. It is also quite different when talking about a metropolitan area system with high outdoor sites, and a premises area system under the control of an owner with ceiling high access-points.

After overcoming this fear, there is a second paranoia which applies to PBX suppliers who for many years have tried to get market acceptance for a PBX that also supplies data service for departmental computers. None of these efforts were accepted by the computer community. What is much more likely to happen is that the high capacity data infrastructure will also supply connection type services (one of which is telephone). Those having concern about their messages going through a central switch should redirect their anxiety to the big internetworking equipment suppliers who have active Asynchronous Transfer Mode (ATM) switch developments and products.

The assumed model for the future is briefly described below. The present situation requires that it be a supported model along with others that have large constituencies.

Table II—Model for the Future

This model is aimed at large scale business and commercial use but adaptable to many different lesser capacity longer reach applications.

The model for the future is that there will be wide area data/voice/video networks based on ATM switches. The proper function for wireless is local distribution from a port on such backbone or "edge" switches. This is the primary problem, and it is not ad hoc autonomous groups meeting to exchange files. All of the services available at a wired desktop must be servable over the radio local distribution system.

One important architectural model starts with a large multi-story building in which the owners or tenants have decided to install a radio access environment throughout the building and providing all service types. There is an ATM "edge switch" with one or more 25 or 155 Mbps ports on the "edge" ATM switch. These ports are used to connect radio LAN and telecom traffic to outside networks.

Each port on an "edge switch" is connected to a local hub-switch with many ports each supporting a radio access-point. The last link in the chain is radio transmission from an access-point to/from a user station at a burst transfer rate of 12 or more Mbps. The area covered by one access-point might be 1,000 to 10,000 ft^2. The smaller the coverage, the greater the capacity and lower the degree of sharing. Many moderately overlapping access-points provide complete area coverage.

The data user requires a data transfer rate above 10 Mbps so that there is slight delay in large numbers of interactive exchanges with a distant site or to download files of many megabits. Since, for one heavy data user requiring 250 Mbits/hour at 12.5 Mbps, channel occupancy is only about 20 seconds per hour, a large amount of time sharing is possible along with quite small access delays (12 milliseconds typical worst case resulting from the reversing period of time division duplex).

This is what the new frequency band should and must support. Widely used narrow band systems are not suited to the short reach and higher radio cost of this band.

One continuous digital connection (telephone call) at 2 x 32 Kbps requires a reservation for 230 Mb per hour. One simplex 12 Mbps throughput channel could serve 100 (50% overhead loss) of these simultaneously, and this is the capacity that can be presented in an area of 1,000 to 10,000 square feet and again in like type adjoining areas. It is more likely that the 50 users that could be contained in this space would use no more than 12 voice connections at one time, and the remaining 85% of the bandwidth would be available for data, fax and video at the 12 Mbps rate. (12 Mbps is an arbitrary number selected differently in other places, and is only an example.)

As will be later described, one coverage area may be allotted only $1/4^{th}$ to $1/16^{th}$ of the standalone capacity because of a provision for frequency reuse. Because different contiguous areas will not require all of their allocated capacity at the same time, this limit will cause less traffic delay than would otherwise be the case. Also half of the time is used for up link and half for down link resulting in halving of the available raw bit rate. When the frame format is based on small cells, the overhead will become a larger fraction of the channel time. It is now estimated that 48 octets of payload will require 12 additional octets of channel time for various radio and overhead functions. All of these considerations reduce the throughput relative to the raw bit rate.

There is an asymmetric relationship between station and access-point transmitter power. *The access-point should have superior power and receiver sensitivity materially reducing the cost and battery drain of the stations. The possibility of interference between station transmitters is also further reduced to a negligible point in determining coverage and capacity.*

2.3 Frequency Division Channelized—Parallel Lower Rate Channels

Notwithstanding negative aspects, channelized systems may better suit the needs of those using longer distances at low information rates. A need of that type would be better served at lower frequencies given suitable unlicensed spectrum. At 5 GHz, a narrow channel might be 2 MHz and accordingly limited in transfer capacity. The rules for such channels must consider cross allocation interference which is possible when such stations are within the service area of wide band systems. On considerations of required crystal accuracy, 2 MHz is a near minimum width.

To the first approximation, a fixed amount of spectrum and modulation technique have the same capacity used in one block whether or not divided into a number of subchannels. This is more accurate for scattered "rug" groups than it is for a "carpet" coverage. In the detail, there can be considerable difference.

The primary inducement for narrow band is increased range or lower power for a given range, but this approximation is only true for classic long reach radio systems. The secondary inducement is that it allows multiple independent and unrelated systems to operate in the same geographic space without objectionable inter-system interference. This is true when the aggregate service demand is a small fraction of the channel transfer rate or a small fraction of the ultimate capacity of the spectrum used.

There are special problems with separate parallel channels. Those not familiar with radio systems assume that each channel can be used independently without considering use made of adjacent channels. If channels are widely enough spaced to make this true, spectrum utilization would be half or a third of what it could otherwise be.

To use separate channels efficiently requires an organized plan which considers that receivers have a limited amount of adjacent channel rejection and cannot withstand other transmitters a few feet away separated by one or a few channels from the operating frequency. Analog radio experience teaches the importance of minimizing dynamic range problems—the ability of the receiver to reject strong signals on another channel while receiving a desired low level signal.

If there are separate channels, it is desirable to have all stations work on all channels. It then becomes desirable to reach stations when it is not known to which channel that station is switched. A whole new layer of protocol is then required to give the system a benefit from the combined capacity of a number of available channels. *Access delay normalized, it is possible for N channels to have far more aggregate capacity then N times the capacity of each channel operating independently.* The ability to use a number of channels collectively to obtain this advantage is absent from the 802.11 frequency hopping PHY standard.

2.4 Point-To-Point Relay Links

The shorter the reach of the end links the more important becomes the option of radio relay links to replace telephone pairs to connect numbers of access-points to a common controller. Without integration and a common frame structure used in both end and relay links, the repeaters will be unnecessarily expensive. Systems such as this should be neither prohibited or defined. The possibility is too valuable to lose.

The combination of relay links serving end links will provide the "community network" capabilities for the services described by Apple in its filings. The use of long reach point-to-multipoint systems are undesirable in this band because of the wide area made busy for other uses. There is a considerable question as to whether point-to-point links in this band should be used as an alternative to expensive high rate leased lines for functions unrelated to end links. The more important question is that if long reach, unlicensed point-to-point service is to be allowed, should the gross inefficiencies of uncoordinated use be allowed. Such links having provably high economic value could become quite numerous and then squeeze out the end link support type of service. This point merits further discussion.

There is considerable usefulness for point-to-point relay links, but they cannot be economical if they are patterned on the telecom model. The first important step is limiting the design range to some maximum well below high-site free space range

With small margin, and with reasonable antenna size, 6-8 km seems like a maximum for 0.1 watt transmitters. Those who need greater reliability can get it with larger antenna diameter to a point or by channel coding, but much more capacity will be available if longer distances are served by more repeaters and shorter paths.

If the 5 GHz end links are largely inside of buildings and point-to-point relay links are largely outdoor and on building roof tops, the same band should be usable for both.

The spatial isolation of the point-to-point links can be increased by use of direct sequence spread spectrum modulation with differing channel coding for external links. This approach is very valuable for *longer reach lower throughput data links*.

Time division duplex and use of the same antenna for both receiving and transmitting should be mandatory. All down links and up links can be made to transmit alternately and simultaneously. Substantial dynamic range problems can be totally avoided for a receiver attempting to pick up a weak signal while another nearby station is transmitting to a different access-point.

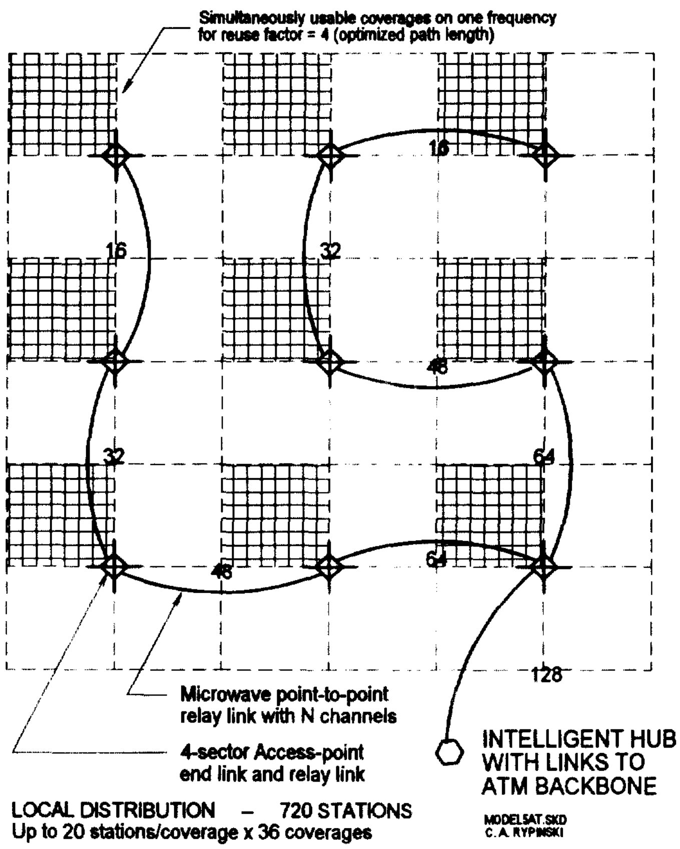

Figure 1 -- System Model for "Carpet" Coverage with Relay Link Support

The above diagram is a model of a continuous coverage radio system with square cells each illuminated from one corner with a quadrantal sector antenna. Four such illuminators can be placed at one point.

At any time, only one in four transmitters is active to provide a frequency use factor = 4 function. Conventionally, a different frequency would be used independently in each of four coverage groups, but this would take four times more spectrum. It would also be impossible to borrow channel time from one coverage to another needing more than 25% of the raw channel capacity.

Minimum cost repeaters would bring all access-point data streams to a common control and switching point. This is required to enable stations to roam from one coverage to the next without effect on access from external networks.

The use of spread spectrum rather than narrow band would decrease the necessary signal-to-interference ratio from 16 to 0 dB greatly improving interference limited operation.

3.0 "Strawman" Frequency Allocation Plan

Shown in Table III below is a possible allocation arrangement. The reasons and considerations for the choices are important than the selected numbers. The value tradeoffs and reasons are presented throughout these comments but mainly in Section 5.0 below.

Table III – Model Allocation Plan for 96-193 Frequencies

Frequency GHz	Bandwidth MHz	Designated Technology and Application	Type No.	Item No.
5.150-5.164	14	7 channels of 2 MHz—point-to-multipoint end links	c)	1
5.164-5.188	24.5	HIPERLAN only Channel 0	a)	2
5.188-5.237	49	HIPERLAN Channel 1 & 2 Open entry for centralized control with access-points May be used for peer-to-peer systems	a) b)	3
5.237-5.286	49	Centralized control, full band, VHR end links Outdoor pt/pt coordinated relay links Interior pt/pt relay links extending SS APs	b)	4
5.286-5.335	49	Centralized control, full band SS end links Outdoor pt/pt coordinated relay links Interior pt/pt relay links extending VHR APs	b)	5
5.336-5.350	14	7 channels of 2 MHz--Point-to-point relay links	d)	6
5.725-5.875	150	Peer-to-peer ad hoc networks	a)*	7

Note: VHR=high rate, LR=long reach, SS=spread spectrum, DCF=distributed control function

Table II – Types of Radio Systems (reference copied from prior page)

a) Peer-to-peer topology primary—deferral based channel access allowed—full band (* Part 15 DS and frequency hopping channelization allowed equally)

b) Centralized control with infrastructure primary—asymmetric up/down links—point-to-multipoint—full band—VHR and DS spread spectrum

c) Frequency division channelized—parallel lower rate long reach channels—point-to-multipoint centralized control

d) Point-to-point systems with fixed high gain directive antennas—full or channelized band—bands limited to outdoor use

3.1 Brief Definitions for the Uses of the Identified Bands

1) Narrow Band End Links

This space is the low side remainder after allocation of HIPERLAN Channel 0--probably defined as a guard band to minimize the interaction between Channel 0 and services below 5.15 GHz. This band is proposed for narrower band (e.g., 7 x 2 MHz bandwidth) point-to-multipoint with directive antennas at the semi-fixed user stations. The reach will be greater than the wider band systems. In combination with band 6), this would be one of the alternatives for part of the community networks defined by Apple.

2) HIPERLAN channel 0 primary

This matches the European allocation for HIPERLAN Type I--peer-to-peer data services.

3) HIPERLAN channel 1 & 2 and DCF open entry

The band should be used as two channels. The band should not require HIPERLAN conformance, but those properties that are required should limit the band use to like power spectrum, power level and transmitter burst length as used in HIPERLAN. This band should be open entry band for any type of distributed control function user station. It could also be the primary band for HIPERLAN Type II with centralized control.

Open entry requires that Access-points and repeaters be allowed, but in this band there is no mandatory functionality for infrastructure control functions. This band may allow use of both/either HIPERLAN Types I or II.

4) Wideband common channel centralized control—high transfer rate

This is the **primary band for wireless ATM** however implemented. It is not required that any particular physical medium rate be matched by the radio. The transfer rate should be as high as possible up to the point where interference resistance to like-type signals is materially degraded.

It is probable that two channels of HIPERLAN Type II will fall within the definitions for this band, but this cannot be known until it is publicly defined

Indoor/outdoor point-to-point use of this same band should be allowed when it is under control from the same point as the end links and can be coordinated. Outdoor point-to-point relay links using DS SS may be allowed in this band for end links which are in band 5).

5) Wideband common channel with centralized control—long reach

This is the **primary band for point-to-multipoint lower transfer rate longer reach data services.** Direct sequence spreading of at least 11 and time or code division modulations should be primary in this band. These constraints also fit the need for outdoor campus inter-building functions and for community networks. The increased channel coding is the way to make the bandwidth-reach tradeoff within a consistent bandwidth and energy density plan.

On a bits/Hz basis, the capacity of an isolated system would make the spectrum efficiency appear low. However on a Mbits/hectare (metric acre area), the much lower required protection ratio and vulnerability to cochannel interference will in the end make such systems comparable to the narrow band methods in band 5). Granting that the transfer rate after spreading might be only 2-4 Mbps, this is enough for many voice or modem speed data circuits which in the aggregate will represent as much capability as in band 5)

This band should be limited to modulations which use the entire allocated band for one carrier at the center frequency, to limit transmitter ON time to that required for a small number of octets in one burst, and to require OFF time after a transmission sufficient for other users to gain access.

Interior point-to-point use of the same band should be allowed when it is under control from the same point as the end links and can be coordinated. Also allowed is exterior point-to-point relay links using the modulations allowed in band 5) serving end links which are in this band.

6) Narrow band point-to-point

This band provides point-to-point support for point-to-multipoint end links furnished in band 1). The use of this band must require time division duplex.

It is possible but not economical for the repeater to simultaneously receive on the low/high band and transmit on the high/low band. Otherwise time coordination between relay and end links will be required.

7) Unrestricted peer-to-peer networks.

This band is already suitable for this service. As is already the case, there should be no regulatory requirement for either presence of absence of infrastructure. It is quite possible for the 802.11 types of physical medium and protocol to be placed in this band, and that should be allowed under existing rules. Since the 802.11 protocol has already been designed for Part 15, the transition to the new band is minimally difficult.

There is a question of whether the HIPERLAN signal should be allowed in this band. It is not a spread spectrum system, however the power is just as much spread as the 802.11 DS medium because of the high data rate. *The regulatory extension of this band for NII might now permit any nominally efficient modulation which spreads the allowed energy over 20 MHz* even though there is not a coding spread function.

Apple has claimed that it needs a separated band in order to provide continuous stream duplex communication. Two frequency duplex is seen to be lower cost relative to the alternatives known to Apple. It is recommended that this argument be rejected, and that no continuous stream point-to-point be allowed at all in any of the subject spectrum, and particularly full duplex as is common commercial and network practice. Instead, time division duplex should be mandatory whether point-to-point or point-to-multipoint.

4.0 "Strawman" Regulatory Envelope for Allowed Uses

For each of the above categories of use, a set of regulatory constraints are required. An attempt is made to suggest a set for each of the above identified bands. The principal followed is first grouping of basic types of service function, and then to devise the least restrictive possible set of regulatory constraints within which different types of solutions may coexist. Reliance is placed on a great deal of geographic isolation of dissimilar solutions because of the creation of Owner's rights within the span of real estate titles.

4.1 General Regulation--Property Owners May Choose Exclusive Technology

The following overriding general regulation *applying just to the 5.15-5.35 frequency band* should be considered:

General Group

> **Within the bounds of real estate property titles, any of the FCC defined services are permitted and use of any FCC type accepted equipment may be used. Within that class, property owners or their agents may define any subset as permissible or not permissible within the space over which they exercise control of personal entry.**
>
> **Property owners may forbid deliberate radio penetration of their perimeter by unrelated external entities and may shield against such penetration.**
>
> **For radio links which pass over unrelated private property, public property or public access property, there is no right of type exclusion for private property owners between origin and destination or for a local government.**

It is important to separate interstate commerce considerations and constraints on radio signals which are entirely contained within the premises of one owner.

The effect of this position can be enormous in utilizing frequency space which would otherwise go unused. This matter is taken up in more detail in following Section 6.0

4.2 General Technical Regulations

The following regulations are recommended for bands between 5.15 and 5.35 GHz. In specific bands, the more restrictive limits are selectively appropriate. These are the outer envelope regulations recommended and also the defaults when not specified.

Group A—Radio Functions

a) No transmitter shall have a steady state ON condition longer than 6 milliseconds for 2 MHz bandwidth channels, or 0.5 milliseconds for wider band channels or an ON time duty cycle of more than 2% for non-traffic system overhead functions.

b) No user station transmitter shall be continuously ON for any period of time longer than that required to transport a data payload of 1600 octets.

c) The maximum allowed transmitter power at the antenna input at any combination of allowed power supply voltage and temperature is 100 mw.

d) Frequency division channelization shall not be further extended beyond the allocated bandwidths defined.

e) Duplex operation must always be provided by time division (and not by frequency division), and the same antenna must be used for transmitting and receiving.

f) There is no limit on allowed antenna gain, but the maximum allowed EIRP is 5 watts on outdoor, fixed location, point-to-point links with beamwidths of 6° or less and on sectoral beam access-points in fixed locations; and 500 milliwatts EIRP for all other cases. The power limit in c) is not suspended by these provisions.

g) Stations with EIRP above 500 milliwatts must provide adaptive power control to reduce transmitter power down to the lowest level that will sustain adequate communication but not lower than 100 milliwatts EIRP.

h) Stations using higher antenna gain than 6 dB must offset the additional gain with reduced transmitter power to stay within the above EIRP limits.

i) Digital modulations or chipping rates in DS/correlation systems shall be better than 0.8 bits/Hz of bandwidth at 26 dB down from mid-channel.

j) Power sensing listen-before-send transmitter ON criteria is permitted by not required.

k) Transmitted carrier frequency shall be accurate within 1% of the channel bandwidth. (e.g., 20 KHz for use of the 2 MHz channels)

l) Radios accessing the 49 MHz wide bands shall be capable of operating at the center frequency of all of these bands or the center frequencies that would be needed if the bands were divided into 24.5 MHz separated half widths. Radios accessing any of the 2 MHz channels shall be capable of operating on any of them in either the high or the low band.

Group B—Control and Protocol Functions

l) Transmission of digitized voice channels using 32 Kbps ADPCM packetized to bundles of 48 octets transmitted at 12 millisecond intervals is recommended but not required. Preferred alternatives would use integer multiples of the dimensions shown.

4.3 Technical Regulations for the 24.5 and 49 MHz wide peer-to-peer bands 2 & 3.

The 24.5 MHz band is intended to carry without change Channel 0 of HIPERLAN but not limited to that particular access method or modulation. The 49 MHz band is intended to be inclusive of either two HIPERLAN channels, or one full bandwidth VHR system. Distributed control functions of any type are allowed. Detail rules for peer-to-peer system are outside of the scope of these comments, however a few important points are offered.

Group C—Radio Functions

a) Except as defined below, the general rules of 4.2 above apply

b) The maximum allowed transmitter ON time enables transfer of 1600 octets of data payload.

c) Repeaters and infrastructure based access-points are permitted but not required.

d) Deferral systems may listen at an access-point in lieu of at each station.

e) The primary use of the 49 MHz band is as two 24.5 MHz bands, but also use as one 49 MHz band is allowed.

4.4 Technical Regulations for the 49 MHz wide VHR (very high rate) band 4.

Group D—Radio Functions

a) Except as defined below, the general rules of 4 2 above apply.

b) This band is for use as one 49 MHz bandwidth transferring data at the highest possible speed consistent with accuracy and reliability constraints and with maximization of area normalized capacity.

c) The maximum allowed transmitter ON time is that required to transfer 256 octets of payload. The preferred ON time is that required for a 48 octet payload.

d) Mutual exclusivity between adjoining coverages shall be centrally managed by time division and not by requiring allocation of or subdivision into additional channels.

e) The preferred form of radio access-point has directivity of 180° or less, and could be required to illuminate a premise from the perimeter inward.

f) A further preferred form of radio access-point will have an electronically positioned directive antenna with separate settings for each associated user station.

g) The preferred form of radio access-point has superior radio performance so that stations may need less power and sensitivity. This will reduce the probability of station-station interference and increase probability that coverage is defined by range from access-point to station only.

h) Point-to-point relay links are allowed to link access-points to the central control function.

Group E—Channel Control Functions

i) No station transmitter shall be able to use the channel for more than three consecutive bursts before other stations have been given the opportunity to use the channel.

j) Overhead for protocol and channel coding shall be less than 60% of each interval of transmitter ON time.

k) The central control function shall be capable of distinguishing allowed user stations from others, and must provide some opportunity for access by unregistered and unassociated guests with like-protocol by which they may request access to be enabled.

l) The central control function shall coordinate up and down link transmission periods so that these intervals are concurrent throughout the controlled system; and moreover the capability to coordinate with other nearby central control functions must also be provided.

m) The duration of the up-down frame sequence shall be 3, 6, 12, or 24 milliseconds with 12 milliseconds preferred.

n) The central control function shall maintain a data base containing the local access route to each authorized and active user. Broadcast is allowed only to define an interval in which stations may request association or service and for system timing reference.

o) The central control must manage time use of each access-point including invitations-to-request service and transmit-enable for specific stations. Time use management shall consider the busy-idle status of adjoining coverages. Use-enabling must be controlled by an algorithm considering message priority and congestion status of the channel.

p) The central control must implement algorithms for fair ways to deal with demand in excess of capacity including reducing capacity allotted to current active users.

q) For systems serving more than 200 user stations, the central control function should be capable of collecting usage statistics on station failed and successful transfers, usage by station, channel time used, peak overload occurrences and delay distributions. Such data is to be available if and when inadequacy of spectrum space is asserted.

4.5 Technical Regulations for the 49 MHz wide LR (long reach) band 5.

Group F—Radio Functions

a) Except as defined below, the general rules of 4.2 above apply.

b) This band is for use as one 49 MHz bandwidth transferring data at a lower useful speed over greater distances consistent with accuracy and reliability constraints and with maximization of area based capacity. (compared with Section 4.4)

c) Mutual exclusivity between adjoining coverages shall be centrally managed primarily by the use of distinguishing spreading codes for each coverage or by time division and not by subdividing the allocation into smaller additional channels.

d) Transmissions in this band shall using a spreading sequence of 11 bits or longer. Use of codes long enough to support 4 to 16 separately detectable patterns are preferred. Such codes and associated modulation shall be chosen so that the aggregate throughput data transfer rate of all derived parallel channels is not less than 10 Mbps.

e) The maximum allowed transmitter ON time is that required to transfer 256 octets of payload. The preferred ON time supports 48 octet payloads.

f) The preferred form of radio access-point has directivity of 180° or less and may be used to illuminate a premise from the perimeter inward

g) A preferred form or radio access-point will have an electronically positioned directive antenna with separate settings for each associated user station.

h) The preferred form of radio access-point has superior radio performance so that stations may have lesser power and receiver sensitivity to reduce the probability of station-station interference and increase probability that coverage is defined by range from access-point to station only.

i) Point-to-point relay links are allowed to link access-points to the central control function.

Group G—Control Functions

j) No station transmitter shall be able to use the channel for more than three consecutive bursts before other stations have been given the opportunity to use the channel.

k) The central control function shall be capable of distinguishing allowed user stations from others, and must provide some opportunity for access by unregistered and unassociated guests with like-protocol by which they may request access to be enabled.

l) The central control function shall coordinate up and down link transmission periods so that these intervals are concurrent throughout the controlled system; and must have a capability to coordinate with other nearby central control functions.

m) The period of the up-down frame sequence shall be 3, 6, 12, or 24 milliseconds with 12 milliseconds preferred.

n) The central control function shall maintain a data base containing the local access route to each authorized and active user.

o) The central control must manage time use of each access-point including invitations-to-request service and transmit enable for appropriate stations. Time use management shall consider the busy-idle status of adjoining coverages. Use enabling must be controlled by an algorithm considering message priority, use history and congestion status of the channel.

p) For systems serving more than 100 user stations, the central control function should be capable of collecting usage statistics on station failed and successful transfers, usage by station, channel time used, peak overload occurrences and delay distributions. Such data is to be available if and when inadequacy of spectrum space is asserted.

4.6 Technical Regulations for Bands 1 & 6 – Two bands of 7 x 2 MHz channels

The lower band is for point-to-multipoint and upper band for point-to-point. Coordination between the two uses is assumed. Most of the regulated properties are the same for both.

Group H—Radio Functions

a) Except as defined below, the general rules of 4 2 above apply.

b) The channels in this band are to be used as a 2 MHz bandwidth transferring data at a lower useful speed over greater distances consistent with accuracy and reliability constraints. The 2 MHz bandwidth may not be further subdivided by frequency division.

c) Transmitters must concentrate at least 95% of the radiated energy within the 2 MHz allocated bandwidth. Colocated adjoining channels are not protected from out-of-band interference between them.

d) Mutual exclusivity between adjoining coverages may be managed by use of 3-7 channels in a frequency reuse pattern in the *point-to-multipoint band only*. Time or code division separation methods may be used in either band.

e) Transmissions in these band may use a spreading sequence of 11 bits or longer. Use of codes long enough to support 4 to 16 separately detectable patterns are preferred. Such codes and associated modulation shall be chosen so that the aggregate throughput data transfer rate of all derived parallel channels is not less than 0.5 Mbps.

f) The maximum allowed transmitter ON time is that required to transfer 256 octets of payload. The preferred ON time supports 48 octet payloads.

g) For point-to-multipoint band, the preferred form of radio access-point has directivity of 180° or less and may be used to illuminate a premise from the perimeter inward.

h) The preferred form of radio access-point has superior radio performance so that stations may have lesser power and receiver sensitivity to reduce the probability of station-station interference and increase probability that coverage is defined by range from access-point to station only.

Group I—Control Functions

i) In an asynchronous system, no station transmitter shall be able to use the channel for more than three consecutive bursts before other stations have been given the opportunity to use the channel.

j) In systems providing an isochronous service, no transmitter may be ON continuously. One connection is allowed one transmitter ON time for a 48 octet payload burst every 12 milliseconds for each 32 Kbps of connection bandwidth.

k) The central control function shall be capable of distinguishing allowed user stations from others, and must provide some opportunity for access by unregistered and unassociated guests with like-protocol by which they may request access to be enabled.

l) The central control function shall coordinate up and down link transmission periods so that these intervals are concurrent throughout the controlled system; and must have a capability to coordinate with other nearby central control functions.

m) The period of the up-down frame sequence shall be 3, 6, 12, or 24 milliseconds with 12 milliseconds preferred.

n) The central control function shall maintain a data base containing the local access route to each authorized and active user.

o) The central control must manage time use of each access-point including invitations-to-request service and transmit enable for appropriate stations. Time use management shall consider the busy-idle status of adjoining coverages. Use enabling must be controlled by an algorithm considering message priority, use history and congestion status of the channel.

o) For systems serving more than 100 user stations, the central control function should be capable of collecting usage statistics on station failed and successful transfers, usage by station, channel time used, peak overload occurrences and delay distributions. Such data is to be available if and when inadequacy of spectrum space is asserted.

4.7 Technical Regulations for Band 7 – ISM Band

This band is already largely defined by Part 15. Except as shown following no new technical position is recommended.

> It is recommended that any signal having the bandwidth and power density spectrum of a compliant DS transmitter also be allowed even though not having the processing gain now required.

5.0 Discussion of Specific Points Pro and Con

There is no one answer for everything. The set of acceptable answers follows from the choice of optimization model and estimates of individual user traffic. The basis for these comments is that:

> New frequencies should be optimized for a much higher level of speed and capacity than can be provided at lower frequencies with narrower channels and longer reach. The alternate of proving more channels that provide the same services will not meet many new needs.

Range considerations will be different at 5 GHz. At lower frequencies it is possible to serve non-optical paths with sufficient power margin. In this band there will little possibility of forcing coverage of shadowed areas with power margin. Further, the indirect paths will probably make accurate data transmission much more difficult because of the time dispersion of reflected paths.

The range of 5 GHz systems will be mostly determined by obstacles and barriers. The coverage beyond that point will not be useful or predictable. For this reason, the common translation between power change and range will not fit most actual situations beyond the first barrier.

5.1 Limitations Of Peer-To-Peer Distributed Control Radio Systems

This class requires that a station about to transmit listen-on-the-channel and defer by a randomized delay interval after the channel goes idle before transmitting. Refinements include adaptively increased threshold levels and modifying backoff time for priority or delayed access. The UTAM bands "etiquette" and the proposed 96-193 etiquette are within this class.

The main reason that the deferral based systems cannot provide high spectrum utilization is that a distant station transmitter can cause interference and deferral at 4 to 16 times the usable service range of each station. With the distributed control characteristic of peer-to-peer operation, all stations will tend to use the same transmitter power operating near the highest allowed. In a large scale system, the channel will seem perpetually busy to a monitor. At the same time and in an interference environment, two stations that are close to each other can still communicate whether or not there is background interference. The capacity loss occurs because proximity is common, and there will be large numbers of deferrals when communication is possible. This loss can only be reduced slightly by using more intricate adaptive threshold algorithms. Without the deferral, the loss from one station transmitting over another will be much smaller than the lost opportunity to use the channel successfully.

Many advocates do not appreciate that in a "carpet" coverage, only 1-in-25 of the signals heard are likely to be from the members of one group. The danger of a sending station not hearing an interferer that can be heard at the receiving point (the Kleinrock "hidden" station) is both tiny and irrelevant (except in overlaid systems). Given that such an interferer is present, it is still possible for the destination station to successfully receive the message—when the destination station is not too far away from the originating station. *The channel time lost from unnecessary deferral is the big inefficiency.*

The conditions under which the deferral system will work is when: 1) the aggregate traffic load is a small fraction of the medium transfer capacity, and 2) the covered area is bounded or isolated by walls and of a size coverable by one access-point. This circumstance will be common in the first years but will disappear with time. The need for this type of system is now served by Part 15.

A further consideration is power control. It is obvious that it is desirable for transmitters to use no more power than necessary, however the design of effective algorithms for peer-to-peer systems is difficult. The problem is that the power required is different for each station-pair in communication, and is therefore wholly unusable for LAN broadcast messages. The function is dynamic and required in every station. After these considerations, automatic power control in stations is complicated and provides only small advantage. Considerable time overhead and protocol is necessary for the control and communication required. It is worth a great deal of effort (e.g., asymmetry of station-AP transmitter power) to avoid station power control.

The presence of a central control entity for the access-points is required for organized frequency reuse, and this is not present in a peer-to-peer system. The concept of cells requires that there is a stable defined coverage for each cell. This is one of the fundamental reasons that unorganized systems cannot approach by an order of magnitude the utilization of coordinated systems.

The unorganized system is what has been defined in IEEE 802.11 and in HIPERLAN Type I.

5.2 Benefits of Centralized Contol and Access-point Infrastructure

In a centralized control system, the station is enabled to transmit by permission messages or other indicator of channel availability in the received data messages from a central controller via a local access-point (a simple base station). Such systems are normal practice in radio telephone systems, and a rarity in packet data systems. The use of an access-point alone does not automatically make a system centrally-controlled. In the model assumed, the access-point is bit stream transducer between the radio frequency and telephone pairs linking it to a multi-port central controller or switch.

There is a large gain when access-points act as shared repeaters with privileged antennas at greater height (ceiling or rooftop) than most stations. *The service range between user and access-point is much greater than the range between two users.* This effect may be further extended by making the radiated power for user stations considerably less than that at access-points. With this power difference, the range may be made the same for up and down paths with better receiving systems at the access-point. Both of these considerations greatly diminish the probability that user stations will interfere with each other when used simultaneously in nearby cochannel coverage areas.

With the shared repeater, the coverage is entirely defined by that of the access-point. With a peer-to-peer group there are no stable coverage borders. The maximum usable geographic dispersal is that where any one station can hear all others sufficiently well to exchange messages. In practice this definition gives an indefinite answer. Adjoining groups of this dimension will cause deferral in both groups, and each will get half of the capacity in a single channel system. The deferral possibilities become much higher if a continuous carpet of such groups is assumed.

About 25 to 100 such nearby groups will cause deferral in a central group even though most are too far away for useful data exchange.

The station power control situation is quite different with an asymmetric system where each station usually communicates with an access-point rather than another station. Because of the asymmetry and short range stations, the system gets little benefit from station power control.

5.3 Frequency Division vs. Time Division

It is common to argue that that an available frequency space should be divided into channels to accommodate different markets, technologies or user groups. A technical argument used is that a number of channels (e.g., seven) are necessary for continuous coverage over an area as with cellular systems. The seven channels may be necessary to accommodate seven different user groups who are unwilling to cooperate, but there is no valid technical argument.

To the first approximation, a fixed amount of spectrum and modulation technique have the same capacity used in one block or in a number of channels. This is more accurate for a number of scattered "rug" groups than it is for a "carpet" coverage. In the detail, there can be considerable difference.

The primary inducement for narrow band is increased range or lower power for a given range, but this approximation is only true for classic long reach radio systems. For 5 GHz microwave systems, indirect propagation via reflection from a number of obstacles may not be usable for data functions because of multipath time dispersion distortion. Moreover, the power required for 30-60 dB signal level margins over free space is unlikely to be available in the microwave band, and this margin is what enables mobile systems to work in shadows.

The secondary inducement is that it allows multiple independent and unrelated systems to operate in the same geographic space without objectionable inter-system interference. This is true with unlimited spectrum, and not true when the capacity demand becomes more than about 15% of the capacity of the allocated spectrum in an isolated group. The situation for carpet coverage is much more biased against channelization.

With time division, unused capacity is in a common pool that may be dynamically allocated rather the subdivided by user group. Such group definitions are inherently variable. It is quite possible for one group to need more than its share of the block capacity while another is using only a fraction. In a carpet system, with *unequally distributed user density*, there is no possibility of efficient use of the spectrum resource with channelized frequency reuse, but there is with time division.

Suppose the existence of a reuse plan which is a square of 4 cells. With time division, each of the cells is activated one-fourth of the time in sequence at four times the speed relative to a frequency division channel per cell where each cell operates all the time. *Since the cells in time division do not operate simultaneously, there is not the receiver selectivity problem in discriminating against an adjacent channel that is inherent in frequency division.*

These considerations are part of the basis for recommendations made in these comments.